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Location Decisions of Energy-Intensive Manufacturing Firms: Estimating the Potential Impact of Electric Utilities Deregulation

by

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1. Introduction

The recent deregulation of electric utilities has generated considerable discussion, particularly in the popular media (e.g., Selz, 1996; Fialka, 1996; Holden 1997), but also among economic developers (Whitehead, 1997). Built on the premise of reduced electric energy costs that result from increased competition, deregulation under Federal Energy Regulatory Commission (FERC) Orders 888 and 889 of April 24, 1996, promises to increase aggregate consumer welfare both through reduced residential energy expenditures and through lower prices of goods as manufacturers pass savings on electricity bills on to their customers.[1] In addition to these immediate effects, deregulation has the potential to alter the spatial distribution of manufacturing activity, creating winning and losing communities in the process.[2]

Under a deregulated electricity generation, transmission and (retail) distribution (GTD) system, firms can purchase electricity from the lowest-cost supplier, who in principle may reside anywhere in the nation. Owners of manufacturing firms who previously sought out regions because of their low electricity rates are no longer bound to such regions because, at least theoretically, the entire nation now comprises the service area of a given electricity supplier, and rates are expected to converge over time nationally to the same level.[3]

[1]Order 888 relates to "stranded costs" and open access to the power grid, while Order 889 addresses information sharing on transmission capacity via electronic means (see EIA, 1997). Estimates of the magnitude of total stranded costs vary from $10 to $500 billion (EIA, 1996, p. 78).

[2]In the past, manufacturers have used the threat of relocation to bargain for lower electric energy rates from local utilities (EIA, 1996, p. 36, quoting Kuhn, 1996).

[3]In practice, engineering considerations and physical laws of electric energy transmission will make it economically unfeasible for a generating plant, say in Florida, to supply the West Coast with energy.

Regions which previously enjoyed a comparative advantage in recruiting manufacturing industries by offering low electricity rates no longer have such an advantage, and may not only attract fewer firms under deregulation, but may even lose firms to other regions of the country. For example, the northwestern states of Washington, Oregon, Montana and Idaho had among the lowest electricity rates in the nation in 1995, averaging 4.38¢ per kWh, well below the national average of 6.89¢ (EIA, 1997). If rates decline in formerly high-cost regions–such as New England–in a competitive national market, firms may leave the northwest for the northeast if the latter region offers greater abundance of other inputs. More specifically, profit-maximizing footloose firms which were once attracted into an area by low electric rates have incentives under deregulation to seek locations at which other scare factors of production are more abundant, or where proximity to customers reduces transportation costs.

This paper examines the location decisions of a certain class of manufacturing firms – those that use a relatively large share of electric energy among their intermediate inputs – and identifies factors systematically associated with new establishment locations in recent years. A key question is whether electric energy-intensive firms will relocate to take advantage of lower electricity rates, creating a "sucking sound" of firm relocations (Holden, p. B6):

> Utility executives agree that if neighboring states have essentially the same mix of environmental restrictions, taxes and regulation, they will likely have similar electric rates. If that mix is changed to bring savings of, say, 20% due to regulation, businesses thinking of relocating will quickly start to favor the state with the cheaper power. Industries for which electricity is a major expense, such as aluminum smelting and grocery retailing, are particularly sensitive to power price swings.

In a similar vein, Whitehead (p. 58) maintains that:

> As site selection projects become more capital intensive, electric power issues have taken on increased importance, in terms of power cost and availability as well as reliability of service. In the past, electric power costs typically amounted to only 3-4 percent of geographically

> variable costs. Today, as companies increasingly seek productivity improvements by replacing workers with power-intensive machinery and equipment, it is not unusual to have electric power consumption represent 5-10 percent of the geographically variable costs.

These quotes suggest that an analysis of location decisions of firms using electric energy intensively may provide useful indications about the effect of deregulation on industrial restructuring. In particular, it may provide early warnings to communities facing the loss of such firms, and also suggest which communities may gain economic activity in a deregulated environment.

2. Modeling Firm Locations Decisions

While a rich literature exists on manufacturing firm locations decisions in the U.S. (e.g., Blair and Premus; Herzog and Schlottmann; Goetz; Fox and Murray; Bartik; Calzonetti and Walker), no study focuses specifically on the location decisions of manufacturers who rely heavily on electric energy in their production processes. Consequently, no previous work can be consulted to help guide the specification of the estimating equations, and instead general firm location principles are used here based on theoretical considerations. Both the specific manner in which the dependent variable is defined and measured, and the regressors to be included in the econometric equations are discussed in detail.

2.1. *Modeling the Dependent Variable*

The dependent variable in this study is the county-level net change in the number of energy-intensive establishments between 1988 and 1994. This time frame is dictated by four considerations: First, at the time this study was initiated, 1994 was the most recent year for which sufficiently detailed county-level data were available. Second, to better represent emerging industries, modifications were made to the Standard Industrial Code between 1987 and 1988, leading to a discontinuity in the time series data for certain industries over that two-year period. Third, Bartik (1991) maintains that between one and six years is an appropriate period over which equilibrium is restored in an economy in response to an initial shock. Fourth, the choice of 1988 as the starting year over which growth is examined corresponds well with data availability, including the 1990 Census of Population and the 1987 Census of Manufacturers.

The specific four-digit SIC energy-intensive industries were selected in a two-step procedure. First, the top two-digit major industry groups in terms of energy-intensity ratios were selected from Table 2 (p. 10) in Energy Information Administration (1995); Gellings (1994) contains related data. Energy-intensity ratios are calculated as thousands of BTUs of energy used per dollar of value of shipments in 1991, with electric energy converted using the generating plant's BTU-equivalent. The five SIC industries groups are, with the energy-intensity ratio reported in parentheses: *S*26 Paper and Allied Products (26.01%); *S*28 Chemicals and Allied Products (16.99); *S*29 Petroleum and Coal Products (23.43); *S*32 Stone, Clay and Glass Products (21.90); and *S*33 Primary Metal Industries (28.37).

In the second step, the national input requirements matrix from IMPLAN (MIG, Inc., 1995) was used to calculate, for each sector in the five two-digit industry grouping identified above, the share of electricity consumption as a percent of all intermediate inputs. This required matching the IMPLAN-specific sectors with Department of Commerce SIC codes. Any industry consuming more than 5% of its intermediate inputs in the form of electricity is defined as energy-intensive for the purposes of this study. This criterion leads to selection of 31 four-digit sectors. Since the number of counties with net gains and losses is relatively small at the 3- and 4-digit SIC levels, industries were aggregated at the two-digit level for the subsequent analysis, leaving *S*26, *S*28, *S*32 and *S*33.

2.2. *The Explanatory Variables*

In theory, firms choose locations to maximize profits, which in turn depend on spatially-varying product and input prices, as well as transportation charges:

(1) $\pi_i = p_i y_i - v_i x_i - \tau_i$

where π_i denotes profits in the *i*th county, p_i is the price of a composite output produced, y_i denotes the quantity of the output produced; v_i is a vector of input prices corresponding to inputs, x_i; and τ_i is aggregate transportation costs (of both inputs and outputs) incurred by the firm when locating in county i.

For manufacturing firms, profit-maximization usually involves trading off a location close to input suppliers with a location close to consumers of the final product. Depending on the nature of the output produced, firms may locate close to their customers (these are *market*-oriented firms); close to input suppliers (*input*-oriented firms) or somewhere in between (Capps et al., 1988). The latter type of firm is considered to be *footloose* since only a small change in relative input/output prices or transportation charges can induce it to locate elsewhere.

Recent location studies suggest four different categories of variables which need to be considered in modeling firm location decisions (e.g., Goetz, 1997; Glasmeier, 1991). These are (1) market access variables; (2) labor force variables; (3) policy variables; and (4) agglomeration factors. In county-level studies, market access can be measured using availability of highways, railroads or sea ports, and also by household income (or its inverse, the poverty level) as a proxy for consumers' purchasing power. Labor force factors typically include training and skills of workers, average wages, unionization and unemployment rates as well as basic population demographics including race, age and sex (e.g., Partridge, 1994). The cost of electric energy is also included here as a major factor in the location decision of these electric energy-intensive firms.

Policy variables generally include local government revenues and expenditures. As Partridge explains, it is necessary to include both categories to allow for appropriate controls; high levels of government expenditure imply a large supply of public services which, in principle, makes a community more attractive. However, to accurately gauge the value of those services, it is also necessary to consider the cost of providing them, which is accomplished by including local tax levels as a control variable.

Other variables included in this category are state-level measures of corporate tax rates, industrial recruitment incentives offered, and environmental policies. Since certain energy-intensive firms are also heavy polluters, a state's environmental policies are especially important in this kind of study. On the one hand, pro-environmental policies should deter locations by raising costs of manufacturing. On the other, states that already have stricter environmental policies may be less likely to enact even tougher policies in the future, so that less uncertainty surrounds the decision to locate in those types of states.[4]

The last category of variables, agglomeration economies, measures the effect of cost-savings or extra costs that arise by locating in close proximity to existing firms in the same industry. Additional agglomeration measures included here are population size of the county, and population density to proxy for land costs (along with median housing values). In this study, measures of rurality and adjacency of non-metro counties to metropolitan areas are also included to capture effects of disagglomeration economies.

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[4]A similar argument has been made in the context of unionization.

In addition to a larger model (see appendix table A for regressors), an auxiliary "short" model is estimated, which contains only a minimum of explanatory variables. This model represents a test of the above quote from Holden (1997), and contains only seven regressors: the price of energy; environmental policies; state and local revenues and expenditures; the poverty rate; population size; and the number of existing establishments in the industry modeled.

2.3. *Statistical Estimation Strategies*

Some counties experienced a net loss of high-tech establishments, others had a net gain, and many experienced no net change between 1988 and 1994. A straightforward way of modeling these events is to use the net change in the number of firms as the dependent variable (*S*nn*chg*, where nn=26, 28, 32 or 33), which ranges from $-\infty$ to $+\infty$, and estimate this equation using Ordinary Least Squares (OLS). This means, however, that the same equation is forced to explain both net gains in establishments as well as net losses, which is a stringent requirement. More specifically, there is no *a priori* reason to believe that the forces determining new firm locations are necessarily the same as those explaining firm losses. The latter may depend more on the national business cycle and global conditions than characteristics of the local economy (see also the related discussion in Partridge). The primary statistical estimation procedures employed in this study are the probit and Tobit maximum likelihood methods.

The Tobit estimator forces a given regressor to determine both the probability that the non-censored event is realized (i.e., that establishment growth occurs), and the amount of that event (the number of net new establishments). By estimating the probit and Tobit models using the same data set additional insights into firm locations may be obtained which would not be realized if only the Tobit model is estimated (see, e.g., Goetz and Morgan, 1995; Goetz and Debertin, 1996; and Goetz and Kemlage, 1996). These issues are discussed at greater length in the unabbreviated version of this paper, which is available from the author.

3. Estimation Results

3.1. *Short Model*

OLS and Tobit estimation results for the "short" model are presented in table 1. The state-level price of electric energy, according to the Tobit estimates, significantly influenced firm location decisions between 1988 and 1994 for the industry groups studied, with the exception only of the *S*26 group. Thus, higher energy costs jointly reduced both the likelihood of net establishment growth and the net number of establishments locating in a county. This result holds after controlling for environmental policies which, surprisingly, had an effect opposite to that expected: states with stricter policies were more likely to attract energy-intensive establishments. A plausible interpretation, as suggested earlier, is that firms prefer to locate in states (and counties) which have enacted stricter policies, since that reduces firms' risk of facing tighter and more costly regulations in the future. At least for *S*33, local government tax and expenditure policies have predicted effects on firm locations.

3.2. *Full Model*

To explore further the effects of other variables traditionally considered in location decisions on net changes in energy-intensive firm locations, the longer models described above were estimated. Due to space limitations, detailed results are reported below only for *S*32 (table 2); results for the other industry groups are available from the author. Electric energy-intensive manufacturing establishments respond in a statistically significant manner to availability of infrastructure (although to varying degrees), labor force demographics, state and local tax and spending policies, and especially to the degree of rurality, population density, population size and existing firm numbers. In contrast, firms do not respond to state-level incentives and, most noteworthy, to energy prices, after all of the other variables identified in table 2 are held constant. Even so, the coefficient estimates for the price of energy are negative as expected. A plausible reason for this is that the energy price is measured at the state-level and therefore does not exhibit enough variation in comparison with the other regressors, for which county-level data are available. Thus, it would not be prudent to conclude from this analysis that energy prices do not matter, particularly in view of the findings reported for the "short" model in table 1.

More specifically, this study suggests that if energy prices converge nationally to the same level under deregulation, counties with the following characteristics may have greater odds of attracting firms in the ***S*32**–Stone, Clay and Glass Products industry: Counties with interstate highway access; lower shares of elderly, young, males, unionized, rural and metro-non-adjacent populations; higher unemployment rates; lower total revenues but higher general debt as a share of income; less strict environmental policies; higher median housing values; lower population densities but larger total populations; and fewer existing *S*32 establishments.

4. Summary and Conclusion

Rural areas, and areas not adjacent to metro areas appear to be especially vulnerable to losing electric energy-intensive manufacturing firms–or not gaining new ones–in a deregulated environment if they are unable to compete on the basis of low-cost energy, all else equal. Thus, if rural areas once had an advantage in attracting these types of firms by offering inexpensive power, that advantage is now lost. Basic labor force demographics, especially the share of young and elderly in the population, exert a strong influence on the location decisions of these firms. More immediate policy levers available to state and local governments to influence location decisions include the balance between taxes raised and public expenditures, and the prevalence of basic transportation infrastructure.

Table 1: OLS and Tobit Results for Energy-Intensive Firm Locations, "Short" Model

	*S*26*chg*	*S*28*chg*		*S*32*chg*		*S*33*chg*	
Variable	OLS	OLS	Tobit	OLS	Tobit	OLS	Tobit
Constant	0.077	0.420***	0.443	0.514*	2.296**	0.422**	1.519*
	(1.51)	(2.86)	(0.51)	(2.11)	(2.79)	(2.78)	(1.64)
PEnergy	0.004	−0.038†	−0.430*	−0.013	−0.336*	−0.054*	−0.645**
	(0.40)	(1.31)	(2.52)	(0.27)	(2.11)	(1.80)	(3.57)
GRNPOL	−0.188*	−0.329	−3.142*	−0.235	−5.695**	−0.011	−3.144*
*10,000	(1.91)	(1.17)	(1.94)	(0.50)	(3.68)	(0.04)	(1.83)
TOTREVPY	−0.026	0.989	2.536	−0.834	−10.38*	−0.703	−14.25**
	(0.11)	(1.44)	(0.58)	(0.73)	(2.35)	(0.99)	(2.92)
GENEXPPY	−0.094	−1.316*	−4.938	−0.022	−0.318	0.316	7.460†
	(0.36)	(1.75)	(1.00)	(0.02)	(0.07)	(0.41)	(1.60)
POVRATE	−0.066	−0.471*	−8.228**	−1.049**	−8.652**	−0.572**	−7.857**
	(0.95)	(2.36)	(5.79)	(3.17)	(6.49)	(2.76)	(5.18)
POP88	−0.136**	−0.089	1.267**	1.468**	2.982**	0.369**	2.300**
*1,000,000	(6.27)	(1.11)	(3.94)	(7.38)	(5.02)	(3.56)	(5.05)
*S*26	−0.130**						
	(16.2)						
*S*28		−0.070**	0.023				
		(10.7)	(0.85)				
*S*32				−0.099**	−0.050*		
				(11.5)	(1.89)		
*S*33						−0.176**	−0.078**
						(30.7)	(2.86)
σ			2.606**		2.862**		2.528**
			(21.08)		(28.69)		(18.85)

Statistical significance levels: *=10%, **=1% or lower; †=10% or lower in a two-tailed test. Asymptotic *t*-statistics are shown in parentheses. A singular Hessian was obtained for *S*26 during Newton iterations for the Tobit model.

Table 2: Location Model Results for S32 Firms (Stone, Clay and Glass Products)

Variable	OLS	*t*-stat	Growth Tobit	*t*-stat	Growth Probit	*t*-stat	Decline Probit	*t*-stat
Constant	0.562	0.72	10.71**	2.91	4.254**	3.00	4.148**	2.68
HWY_DUM	0.035	0.83	0.243†	1.44	0.083	1.26	0.129*	1.77
RAIL_DUM	−0.083*	1.88	−0.165	0.86	−0.062	0.82	0.226*	2.48
PORTS	−0.139	0.50	−0.024	0.07	−0.011	0.08	0.141	0.96
OLDER 0.191	0.21	−8.552**	2.88	−3.878**	3.33	−3.870**	2.89	
UNDER18	−0.693	0.71	−10.12**	2.95	−3.775**	2.81	−2.782*	1.83
WHITEPER	0.435*	2.14	2.251**	2.80	0.797**	2.60	−0.071	0.21
MALEPER	−0.863	0.80	−18.20**	2.75	−7.308**	2.88	−5.336*	1.99
COLLGRAD	1.443*	1.73	1.195	0.68	−0.180	0.26	−0.928	1.18
HSONLY	0.174	0.34	1.925	1.05	0.668	0.94	−0.899	1.15
POVRATE	0.005	0.01	−1.962	0.90	−0.614	0.73	−1.731*	1.80
UNEMRATE	1.683**	2.62	9.674**	2.82	3.215*	2.44	−1.250	0.79
ERNPROD2	0.006	0.49	0.037	0.87	0.020	1.22	0.021	1.15
UNION88	−0.682*	2.03	−1.789*	2.32	−0.419†	1.37	0.477†	1.42
TOTREVPY	−0.691	0.77	−9.441*	2.17	−3.958*	2.21	−1.520	0.79
GENEXPPY	−0.432	0.43	1.005	0.23	0.748	0.41	1.857	0.94
GENDEBPY	0.123*	1.76	0.867*	2.04	0.308*	1.82	0.069	0.37
CORPMART	−0.005	0.50	0.028	1.00	0.011	0.94	0.010	0.79
INCEN2	0.005	0.52	−0.023	0.72	−0.011	0.84	−0.001	0.09
GRNPOL	−7.74e-05	1.22	−4.96e-04**	2.63	−1.56e-04*	2.10	−1.30e-04	1.56
PEnergy	−0.013	0.26	−0.204	1.19	−0.071	1.06	−0.066	0.86
PERRURAL	−0.208†	1.45	−2.052**	5.49	−0.715**	4.94	−0.623**	3.82
NONADJ	−0.113**	3.00	−0.609**	3.21	−0.195**	2.68	−0.110	1.34
MEDVAL	7.08e-07	0.36	5.97e-06*	1.83	3.70e-06**	2.67	−1.13e-06	0.73
POPDEN	−1.64e-04**	3.79	−2.78e-04**	2.66	−1.26e-04**	2.77	1.19e-04**	3.00
POP88	1.93e-06*	2.15	2.09e-06**	3.33	7.95e-07**	2.93	−2.17e-06**	7.56
*S*32	−0.113**	2.98	−0.044*	1.70	−0.029**	2.60	0.113**	9.44
σ			2.685**	29.02				

Statistical significance levels: *=10%, **=1% or lower; †=10% or lower in a two-tailed test.

Appendix Table A: Description of Regressors, Summary Statistics and Data Sources

Variable	Description		Mean	Stdev.	Source
Market Access Variables					
HWY_DUM	Interstate Highway access	(+)	0.427	0.495	DoT[i]
RAIL_DUM	Railroad indicator variable	(+)	0.764	0.425	DoT
PORTS	Seaport access indicator variable	(+)	0.039	0.195	DoT
Labor Force Variables					
OLDER	Population older than 65 years, 1990 (% of total)	(−)	0.150	0.043	CoP[a]
UNDER18	Population 17 years and younger, 1990 (%)	(−)	0.269	0.034	CoP
WHITEPER	Population that is white, 1990 (%)	(±)	0.876	0.152	CoP
MALEPER	Population that is male, 1990 (%)	(±)	0.490	0.016	CoP
COLLGRAD	College graduates, 1990 (% of popl. 25 years or older)	(+)	0.134	0.064	CoP
HSONLY	High school grads., 1990 (% of popl. 25 yrs. or older)	(+)	0.562	0.075	CoP
POVRATE	Poverty rate, 1990 (%)	(−)	0.168	0.079	CoP
UNEMRATE	Unemployment rate, 1988 (%)	(+)	0.068	0.033	USA CD[b]
ERNPROD2	Manufacturing wage, 1987 ($ per hour)	(−)	8.503	2.146	CoM[c]
UNION88	Unionization, 1988 (% of manuf. workers, state-level)	(−)	0.197	0.122	USA CD
Policy Variables					
TOTREVPY	Total government revenue, 1987 (per dollar of income)	(−)	0.117	0.052	CoG[d]
GENEXPPY	General govt. expenditure, 1987 (per dollar of income)	(+)	0.114	0.048	CoG
GENDEBPY	General govt. debt, 1987 (per dollar of income)	(+)	0.079	0.219	CoG
CORPMART	Marginal corporate tax rate (on $ million)	(−)	5.878	3.026	SDoD[e]
INCEN2	Industrial recruitment incentives (number)	(+)	9.094	2.691	SSM[f]
GRNPOL	Environmental policies index (state-level, 1986-88)	(+)	2287.5	597.3	H&K[h]
Other					
PEnergy	Energy prices (cents per kiloWatt hour); state-level	(−)	3.615	0.528	EIA[g]
Agglomeration Factors					
PERRURAL	Rural residents (% of population)	(−)	0.641	0.293	CoP
NONADJ	Non-adjacent nonmetro county	(−)	0.416	0.493	USDA[j]
MEDVAL	Median housing value ($)	(−)	53191	32656	CoP
POPDEN	Population density, 1988 (residents per square mile)	(−)	194.6	1418.0	CoP
POP88	Population, 1988 (number)	(+)	78410	262220	CoP
*S*26	SIC 26 (energy-intensive) establishments, 1988 (number)	(±)	0.183	0.708	CBP[k]
*S*28	SIC 28 (energy-intensive) establishments, 1988 (number)	(±)	0.776	3.162	CBP
*S*32	SIC 32 (energy-intensive) establishments, 1988 (number)	(±)	1.528	6.014	CBP
*S*33	SIC 33 (energy-intensive) establishments, 1988 (number)	(±)	0.995	4.698	CBP

a. Census of Population, 1990; U.S. Department of Commerce, Bureau of Census, Washington, D.C.

b. *USA Counties on CD*, CD-ROM, U.S. Department of Commerce, Bureau of Census, Washington, D.C.

c. Census of Manufacturers, 1987; U.S. Department of Commerce, Bureau of Census, Washington, D.C.

d. Census of Government, 1987; U.S. Department of Commerce, Bureau of Census, Washington, D.C.

e. U.S. Data on Demand, Inc., *State Data on Demand, Guide*, First Edition, McConnellsburg, PA., 1990.

f. *Site Selection Magazine*, October Issue, 1987.

g. Energy Information Administration, Washington, D.C.

h. Hall, B. and M.L. Kerr, *1991-1992 Green Index: A State-by-State Guide to the Nation's Environmental Health*, Washington, D.C., Island Press, 1991.

i. Department of Transportation, Transportation Data Sampler CD-Rom, Washington, D.C., 1987.

j. USDA Beale Code. Ross Cook, P., "1989 ERS County Typology Codes," January, 1995; available at: usda.mannlib.cornell.edu/data-sets/rural/86005/3/typol89.wk1

k. County Business Patterns, CD-Rom, U.S. Department of Commerce, various years (1988-89 and 1993-94).

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